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INSTITUTE FOR DEFENSE ANALYSES

Tanker Aircraft in the Airlift Role

J. Schwartz, Project Leader

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PREFACE

This study of tanker aircraft in the airlift role was performed as an IDA Central Research Project. It was conducted as part of continuing tanker aircraft related analyses since the 1995 IDA Airborne Tanker Study,[1] which was performed for the Office of the Undersecretary of Defense (Acquisition and Technology), Strategic and Tactical Systems, within the Office of the Secretary of Defense (OSD).

The study was performed by Mr. Joshua A. Schwartz. The technical review committee consisted of Dr. David L. Randall (Director, System Evaluation Division), Dr. William L. Greer, and Dr. Kevin M. Eveker. The author thanks the reviewers for their expert advice and helpful suggestions.

[1] *Airborne Tanker Study (U),* IDA Report R-395, SECRET.

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Appendixes

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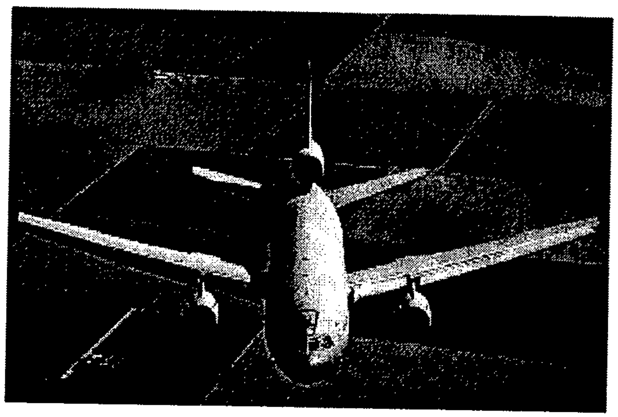
Main Briefing



Some pertinent background for the briefing is shown in this chart. Numerous previous tanker requirements studies--including IDA Report R-395, *Airborne Tanker Study*, 1995, and a series of Air Mobility Command (AMC) tanker requirements studies during the 1994-1995 period--have generally found that the current and planned tanker force (consisting of KC-135E/R and KC-10A aircraft) appears adequate to meet the present Defense Planning Guidance (DPG) requirements for major regional conflicts and strategic nuclear war. The most recent 1998 Air Mobility Master Plan (AMMP) also indicates no tanker aircraft shortfall when they are used purely for aerial refueling (with no other taskings). This is a very different situation than that which existed throughout most of the Cold War, when the tanker force structure was widely considered to be far short of the requirements.

The current KC-135 tanker fleet of approximately 550 total inventory aircraft (TIA) faces continual reduction pressures. While the number of USAF fighters and bombers have declined over 30 percent and 50 percent, respectively, from the mid-1980s to today, the number of tankers have declined less than 15 percent over this time period. This disparity has highlighted the tanker force structure, and some contend that it should be a candidate for further downsizing.

A 1996 GAO report, *Aging Refueling Aircraft are Costly to Maintain and Operate*, concluded that the KC-135 fleet is taking progressively more time and money to maintain and operate. A CBO report, published in the same year, suggested retiring 100 KC-135E tankers as one of the options for reducing spending. The next Quadrennial Defense Review (QDR) may result in further reductions to the potential receiver (primarily fighter and bomber) force structures due to budgetary restraints and spending priorities. Even if these are not made, continuing improvement in receiver fuel efficiencies due to engine upgrades or follow-on replacement aircraft (e.g., F-22A for F-15C and JSF for F-16) are likely. Finally, planning scenario changes may strain retention of the present tanker force structure level.

Before any tankers are retired from service, their overall contribution should be examined. This includes not only their inherent aerial refueling role, but their potential airlift contribution (which is addressed in this briefing) and potential in other areas, such as aeromedical evacuation. While the threat of a large-scale conventional conflict in Europe has subsided (and with it, the likelihood of massive U.S. casualties), aeromedical evacuation could be of heightened concern in the future with increasing threats from biological and chemical weapons.

BACKGROUND

- USAF TANKER FORCE (KC-135E/R, KC-10A) APPEARS ADEQUATE TO MEET CURRENT DEFENSE PLANNING GUIDANCE REQUIREMENTS FOR AERIAL REFUELING (EXCLUSIVELY)
  - Major Regional Conflicts
  - Strategic Nuclear War
- KC-135 TANKER FLEET OF APPROXIMATELY 550 TIA (ACTIVE, ARC, AND ANG) FACES CONTINUAL REDUCTION PRESSURES
  - Increasing Costs (1996 GAO Report)
  - Budget Constraints (1996 CBO Report)
  - Possible Receiver Force Structure Cuts
  - Receiver Efficiency Improvements
  - Planning Scenario Changes
- BEFORE ANY TANKERS ARE RETIRED FROM SERVICE, THEIR OVERALL CONTRIBUTION SHOULD BE EXAMINED
  - Aerial Refueling
  - Airlift
  - Other?

The overall goal of the briefing is to characterize the often overlooked airlift potential of the USAF tanker fleet. The specific objectives of the briefing are threefold and displayed on this chart. The first is to establish the airlift capability of the USAF tanker aircraft, which include the KC-135E/R Stratotankers and KC-10A Extender. The second objective is to compare and contrast the airlift capability of the tanker aircraft with dedicated airlift aircraft, namely the C-141B Starlifter, C-17A Globemaster, and C-5 Galaxy. The third objective is to assess the potential contribution of re-rolled tanker aircraft to the total U.S. airlift capability. Historical examples of tanker usage in the airlift role are to be exposed.

OBJECTIVE

- ESTABLISH THE INHERENT AIRLIFT CAPABILITY OF THE USAF TANKER AIRCRAFT
  - KC-135E/R Stratotankers
  - KC-10A Extender

- COMPARE AND CONTRAST CAPABILITY WITH THAT OF DEDICATED AIRLIFT AIRCRAFT
  - C-141B
  - C-17A
  - C-5A/B

- ASSESS POTENTIAL CONTRIBUTION OF RE-ROLLED TANKER AIRCRAFT TO THE TOTAL U.S. AIRLIFT CAPABILITY
  - Expose Historical Examples of Usage

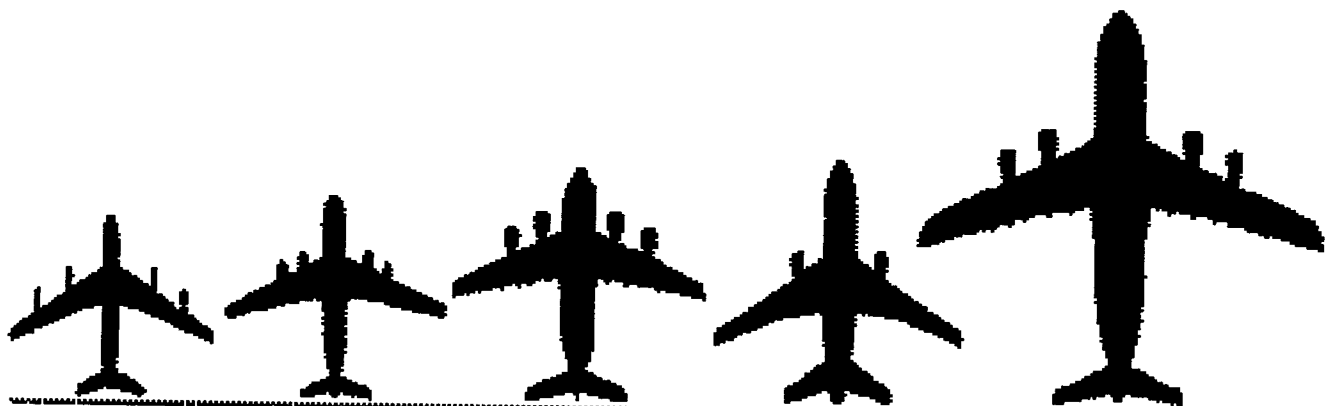
A general comparison of the tankers and dedicated airlift aircraft considered is illustrated in this chart. The top-view schematic of the aircraft is shown at the top of the chart and is roughly to scale. The aircraft are displayed in order of their overall size.

Below the pictures is the absolute maximum takeoff gross weight (TOGW) of the respective aircraft, shown in thousands of pounds. The maximum TOGW for the aircraft track with the overall size of the aircraft. Beneath the TOGW is the nominal fuel consumption (measured in gallons per hour) for each aircraft, taken from Air Force Pamphlet (AFP) 144-4, Attachment 8, *Aircraft Planning Factors,* for all the aircraft except the C-17A. The nominal fuel consumption displayed for the C-17A is an estimate based on the performance specified in its flight manual at an average mission weight. It is important to note that these values are for comparison purposes only, and vary considerably with the aircraft weight, flight altitude, flight speed, and other factors. The nominal fuel consumption also follows the overall size and TOGW of the aircraft.

Next, the nominal ramp space usage (measured in square yards) for each aircraft is shown. These planning factors are from Air Force Manual 86-2 and based purely on the overall aircraft length and wing span. Consequently, the actual ramp space usage may be somewhat different. Nevertheless, the nominal ramp space usage displayed also increases with the overall size and TOGW of the aircraft considered.

AIRCRAFT OVERVIEW

Pictures are roughly to scale



	KC-135E/R	C-141B	C-17A	KC-10A	C-5A/B	
Maximum Takeoff Gross Weight (klb)	297/323	323	580	590	840	Standard Aircraft Characteristics
Nominal Fuel Consumption (gallons/hr)	1,800/1,630	2,075	~2,500	2,650	3,500	AFP 144-4
Nominal Ramp Space Usage (Square Yards)	6,928	10,472	11,295	11,680	21,461	AFM 86-2

The cargo loading characteristics of the tankers and dedicated airlift aircraft examined are listed in this slide. The key characteristics are the number of ramps, cargo compartment dimensions (floor length, width, and height), door dimensions (width and height), cargo deck rollers, and maximum capacity (measured by the absolute payload weight, number of standard 463L pallets, and troop seating).

Unlike the dedicated airlift aircraft, the tankers do not have ramps. Consequently, they are more dependent on the material handling equipment (MHE), particularly loaders, for the on-loading and off-loading of cargo. The total cargo compartment volume and door dimensions in the tankers is generally much lower than those of the dedicated airlifters. The one exception is the KC-10A: total cargo volume and door dimension is somewhat larger than that on the C-141B (which is slated to be retired by the mid-2000s). All the dedicated airlift aircraft and the KC-10A have integral cargo deck rollers, which greatly aid in the on-loading and off-loading of cargo.

A limited number (150) of cargo deck roller kits (with both cargo and omnidirectional rollers) have been procured and are available for use on the KC-135 fleet. With a maximum of six standard pallets or maximum payload weight of about 41 tons, the KC-135 cargo loading capacity is significantly lower than that of the dedicated airlift aircraft. Height restrictions on the KC-135 limit the vertical loading of the pallet up to about 60 inches. The cargo loading capacity of the KC-10A, measured purely by the maximum number of standard 463L pallets and maximum payload weight, is greater than that of the C-141B and C-17A, but less than that of the C-5A/B.

CARGO LOADING CHARACTERISTICS

Aircraft	Number of Ramps	Cargo Compartment Dimensions (ft)				Door Dimensions (inches)		Cargo Deck Rollers	Maximum Troop Seating	Maximum Number of Pallets	Maximum Payload Weight (tons)
		Floor Length	Width	Height	Total Volume	Width	Height				
KC-135E/R	0	66	10	7	5,730	117	78	Kit (150)	80	6	41.5
KC-10A	0	125	18	8	11,528	140	102	Integral	75	27	85.0
C-17A	1	85	18	12.3	20,900	216	148	Integral	102	18	86.1
C-5A/B	2	121	19	13.5	34,796	222	162	Integral	75	36	130.5
C-141B	1	93	10.3	9	8,904	123	109	Integral	177	13	47.3

Sources: USAF Standard Aircraft Characteristics.
Air Force Pamphlet AFP 76-2.

This chart summarizes qualitatively the important airlift capabilities of the tankers and dedicated airlift aircraft. The table is divided into two categories: cargo carrying capabilities and special combat capabilities. The former involves the types of cargo that fit onboard each aircraft, while the latter addresses how cargo is delivered under special circumstances. These include the ability to conduct airdrops of paratroops and equipment, the ability to conduct low-altitude cargo airdrops with a Low-Altitude Extraction System (LAPES), the ability to conduct a combat offload (e.g., to unload cargo while taxiing down a runway), and the ability to fly into and out of austere airfields with short runways.

Both the KC-135E/R and KC-10A can carry passengers (PAX) and bulk cargo. Bulk cargo is normally secured to a standard 463L pallet (measuring 104 inches long, 84 inches wide, and typically no more than 96 inches high), which is then loaded or unloaded as a unit. Oversized cargo exceeds the usable dimensions of the 463L pallet, but is equal or less than 1,090 inches long, 117 inches wide, and 105 inches high. While oversized cargo can be carried on the dedicated airlifters, only some can be carried on the KC-10A and few (if any) can be carried on the KC-135E/R. Wheeled vehicles can be loaded and unloaded under their own power via the ramps on the C-5A/B, C-17, C-141B, and C-17A. Special loaders (such as the 60-K loader) are needed to load and unload all equipment, including wheeled vehicles, on the KC-10A. Outsize cargo exceeds the dimensions of oversize cargo, and requires the use of a C-5 or C-17. Consequently, neither the KC-10A nor KC-135E/R can carry outsize cargo.

The special capabilities reflect duties beyond the routine delivery of cargo to large main operating airfields. While the dedicated airlift aircraft can perform at least some of these functions, the KC-10A or KC-135E/R cannot perform any.

AIRLIFT CAPABILITIES

● Good
◒ Fair/Partial
○ Poor/No Capability

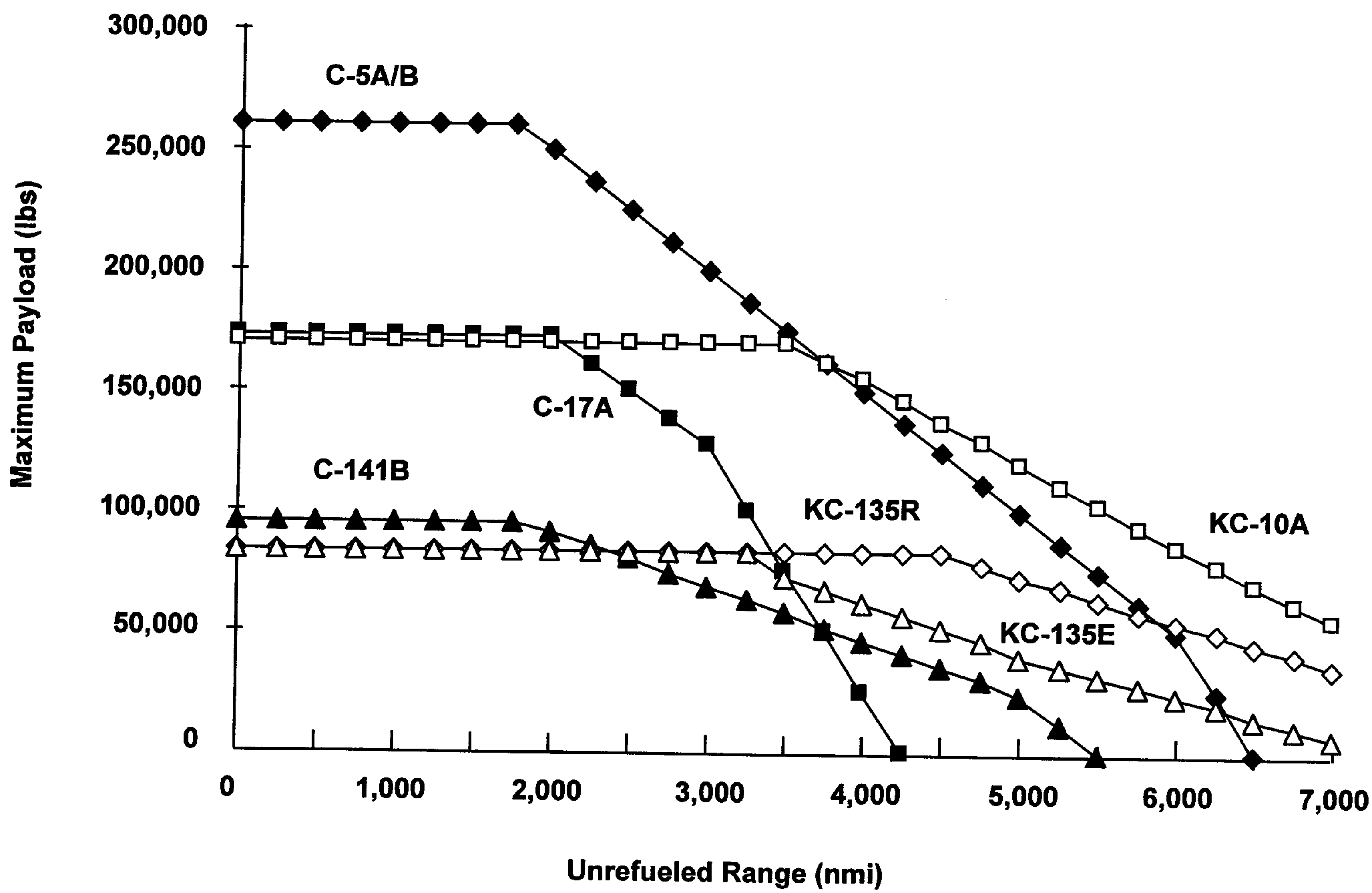
AIRCRAFT	CARGO CARRYING CAPABILITIES				SPECIAL CAPABILITIES			
	PAX	BULK	OVER-SIZED	OUT-SIZED	AIR-DROP	LAPES	COMBAT OFFLOAD	AUSTERE FIELDS
C-17A	●	●	●	●	◒	●	●	●
C-141B	●	●	●	○	●	○	◒	○
C-5A/B	●	●	●	●	◒	○	○	◒
KC-10A	●	●	◒	○	○	○	○	○
KC-135E/R	●	● [a]	○	○	○	○	○	○

[a]With cargo deck rollers installed.

This chart displays the standard range-payload capability for the aircraft examined. For each aircraft, the maximum payload (in pounds) is typically fixed for some unrefueled range band, then it characteristically drops off (as payload is traded for fuel) to the point where the maximum unrefueled range (in nautical miles) is achieved, where the maximum payload is zero. While the maximum payload weight is exhibited for all the aircraft, it must be reiterated that some aircraft can carry more types of cargo (e.g., PAX, bulk, oversize, and outsize) than others (as highlighted on the previous chart). In operation, the maximum payload weight is rarely achieved by any of the aircraft shown due to cargo loading volume constraints. Nevertheless, the highest payload weight is typically obtained by the aircraft when carrying purely bulk cargo (instead of mixed outsized/oversize/bulk or oversize/bulk for those aircraft capable of outsize and/or oversize cargo).

At unrefueled ranges up to about 3,750 nmi, the C-5A/B possesses the highest payload capacity by far of the aircraft considered. For unrefueled ranges over approximately 3,750 nmi, the KC-10A has the highest payload. The KC-135E/R has a low maximum payload capability, but retains it for longer ranges than either the C-17A or C-141B (and eventually even the C-5A/B). The cross-over point for the KC-135R (e.g., the unrefueled range at which it has superior payload capability) is about 2,500 nmi with the C-141B, roughly 3,250 nmi with the C-17A, and approximately 6,000 nmi with the C-5A/B. For missions requiring very long unrefueled ranges, tanker aircraft appear to be the preferred option, and at extreme ranges, the only option (albeit with a small payload). The long range of the tanker aircraft can permit direct delivery of cargo to distant theaters without an enroute refueling stop. This can reduce the time required to deliver high priority bulk cargo or passengers.

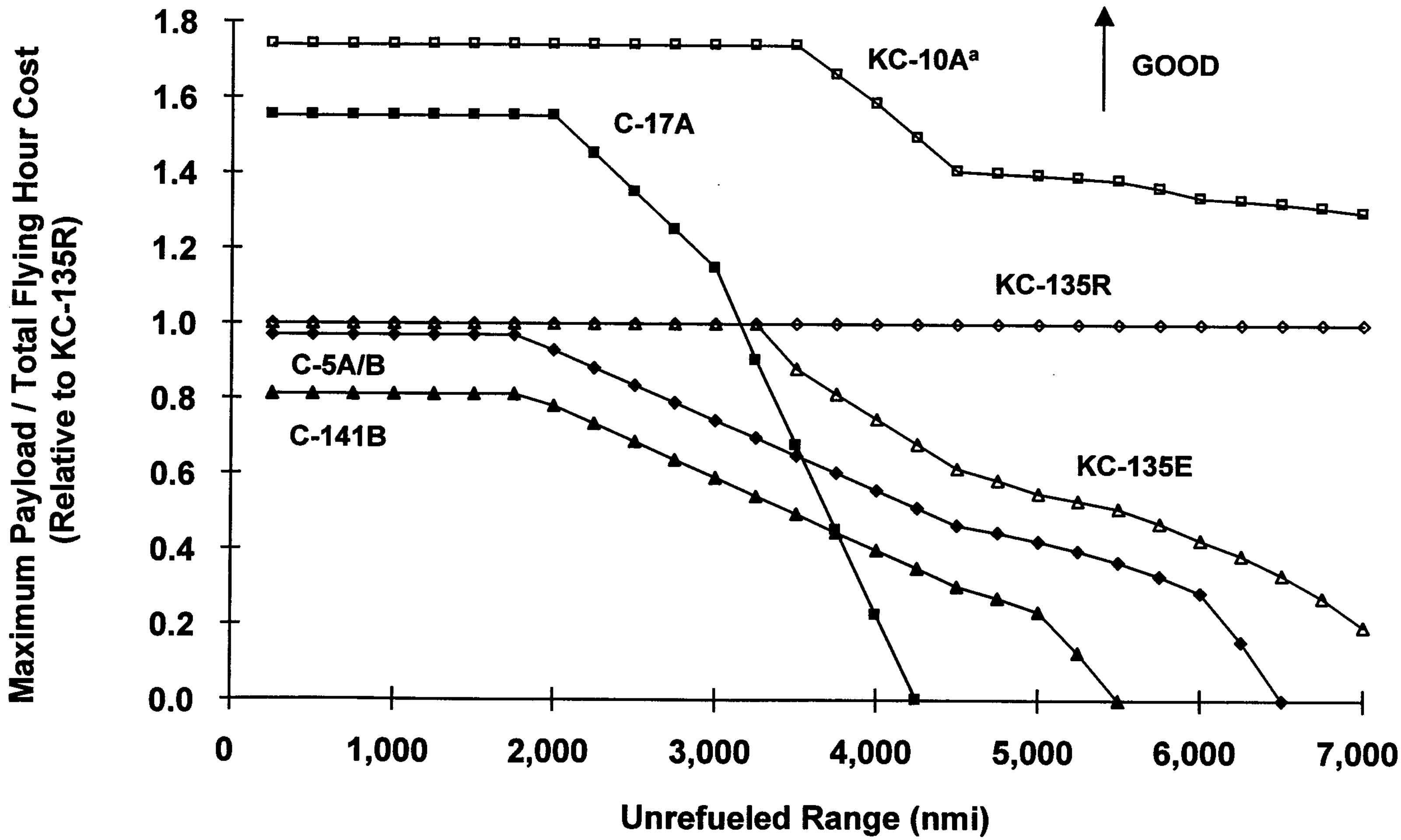
RANGE-PAYLOAD CAPABILITY



The relative payload delivery cost-effectiveness is illustrated in this slide. This is measured by maximum payload weight divided by the total flying hour cost (relative to the KC-135R), and plotted against the unrefueled range (in nautical miles). The maximum payload weights are from the previous range-payload chart, while the flying hour costs are from the USAF Core Model. The Commercial Logistics Support (CLS) costs are included for the KC-10A. Goodness is shown with the arrow; the higher the relative values, the better.

The KC-10A is clearly the most cost-effective of the aircraft examined in terms of bulk payload delivery. The C-17A is the next most cost-effective aircraft for bulk payload delivery up to an unrefueled range of about 3,125 nmi. If oversize or outsize payloads are required, the C-17A would be the most cost-effective aircraft considered up to a range of 3,500 nmi. For unrefueled ranges of greater than approximately 3,125 nmi, the KC-135R is the second most cost-effective aircraft for bulk payload delivery. At these ranges, even the KC-135E is more cost-effective than any of the dedicated airlift aircraft for bulk payload delivery.

RELATIVE PAYLOAD DELIVERY COST-EFFECTIVENESS

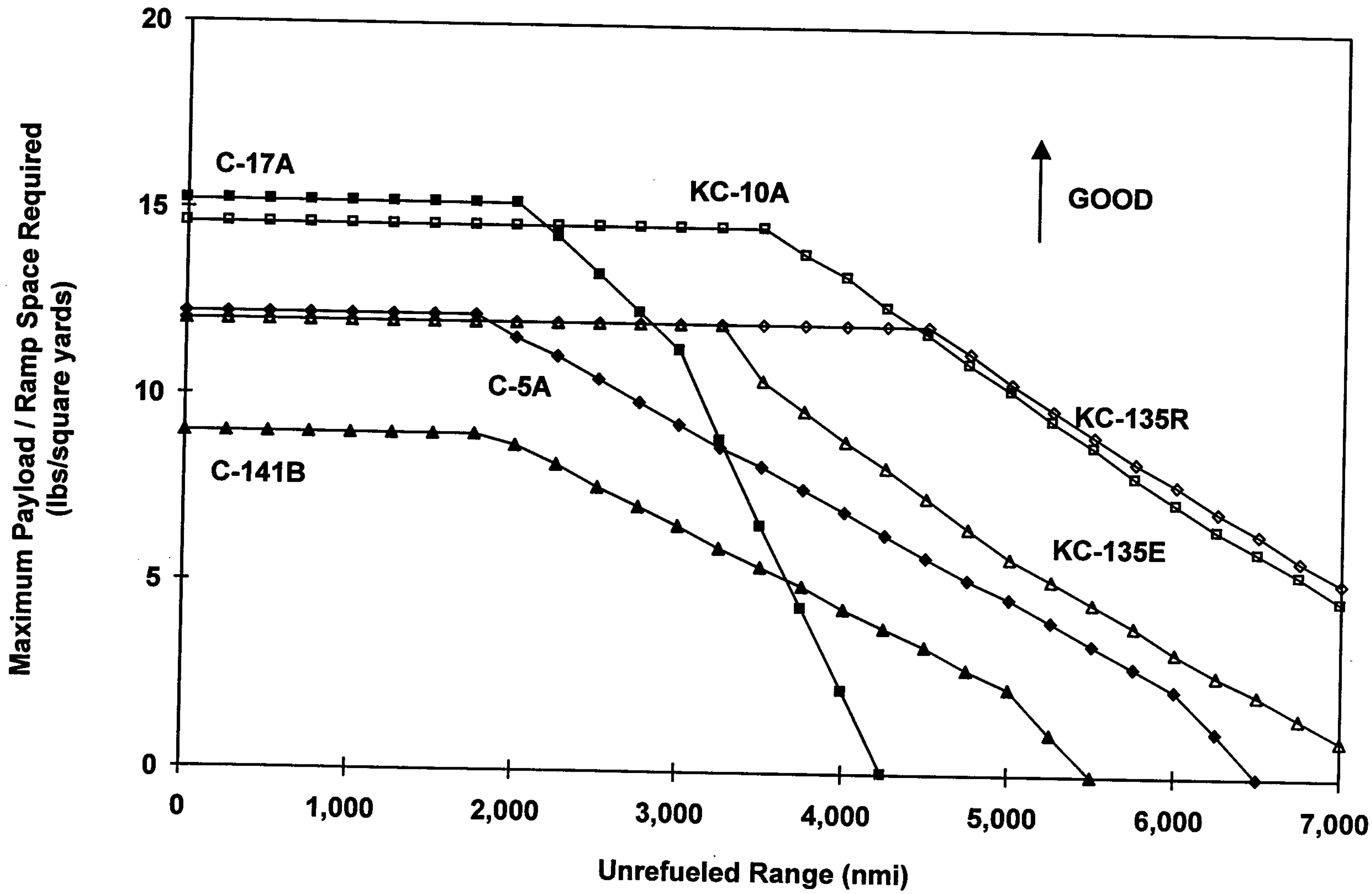


Note: Flying hour costs from USAF Core Model (FY95).
[a]Commercial Logistics Support costs included.

The ramp space use efficiency is depicted on this chart. The ramp space use efficiency is measured by the maximum bulk payload weight (in pounds) divided by the ramp space required (in square yards), and plotted against the unrefueled range (in nautical miles). The maximum payload weights are from the range-payload chart shown previously, while the ramp space requirements are taken from Air Force Manual 86-2 and based on the overall aircraft length and wing span. Goodness is again shown with the arrow; the higher the values, the better.

The C-17A has the highest overall ramp space use efficiency at unrefueled ranges of up to 2,250 nmi. The KC-10A is a close second at these ranges and is the preferred aircraft using this measure at unrefueled ranges from 2,250 to 4,500 nmi. After this point, the KC-135R actually provides a slightly higher ramp space use efficiency. At unrefueled ranges in excess of roughly 3,500 nmi, even the KC-135E provides higher ramp space use efficiency than any of the dedicated airlift aircraft for bulk payload delivery.

RAMP SPACE USE EFFICIENCY



A simplistic method to measure airlift capability is million-ton-miles per day (MTM/D). MTM/D is an aggregate, unconstrained, top-level metric that permits quick comparisons, but ignores the requirements for timing, unit integrity, system interactions, infrastructure constraints, and the differences between bulk, oversize, and outsize cargo. MTM/D is calculated for a specific aircraft type by multiplying the objective utilization rate (average number of flying hours per day per PAA aircraft), block speed, average payload, and a productivity factor, all divided by 1 million nmi.

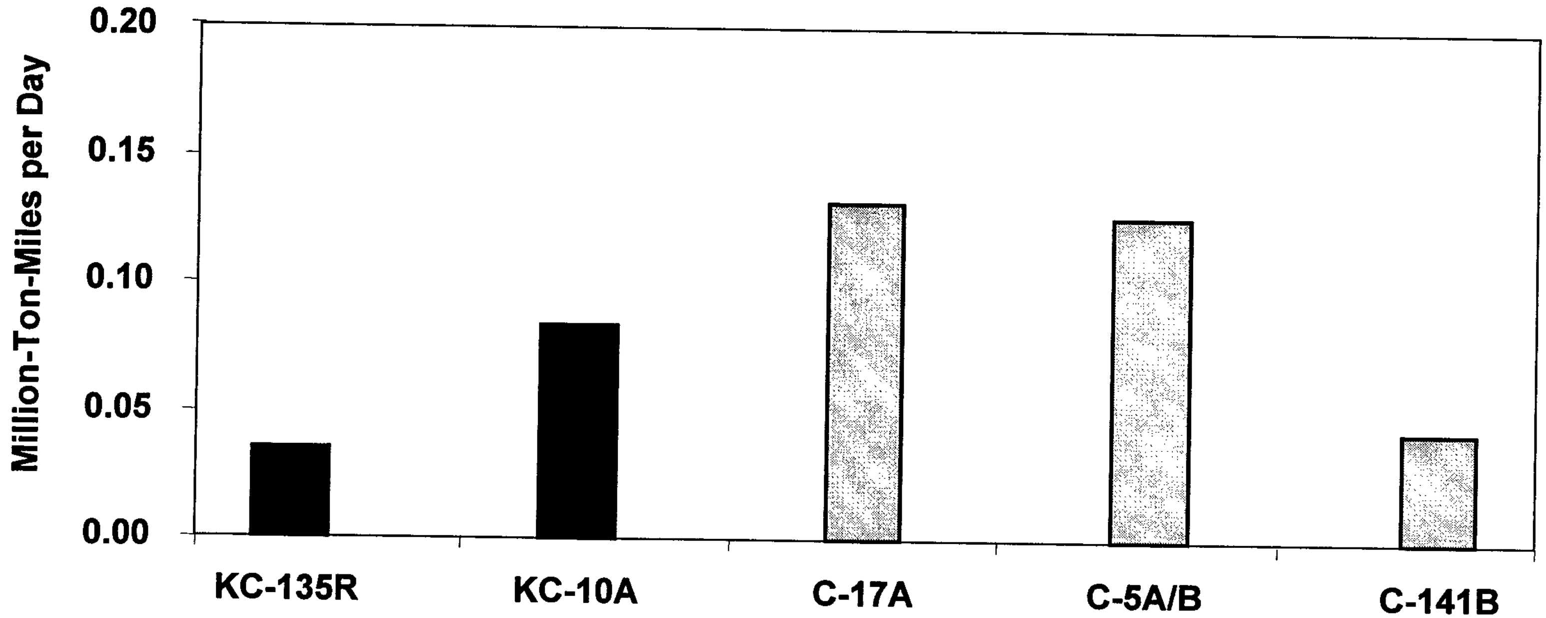
The approximate MTM/D values for the aircraft considered are shown in this chart. For all the aircraft except the KC-135, the values were taken from the most recent (1998) AMMP. The objective utilization rate used in the AMMP was the surge rate (versus the sustained rate). The block speed used was the average ground speed (in knots) from takeoff to a 2,500 nmi average leg distance.

The payload values used were based on operational experience loading aircraft during Desert Shield/Desert Storm. The productivity factor takes into account the aircraft returning empty from the theater and positioning legs to onload locations. A productivity factor of 0.47 was used in the AMMP calculations. For the KC-135, the payload value was assumed to be 14 tons (6 pallets x 2,300 pounds average per pallet), while the utilization rate, block speed, and productivity factor of the KC-10 in the AMMP were used as a surrogate.

As a reference, the total current airlift capacity specified in the AMC AMMP is 26 MTM/D with the organic military airlift aircraft and a nominal allocation of KC-10As. Including the Civil Reserve Aircraft Fleet stages I, II, and III adds about 21 MTM/D, for a total of about 47 MTM/D. This overall capacity increases to just over 50 MTM/D in the mid-2000s as the C-17A is introduced in large numbers into the fleet and the C-141 is retired.

APPROXIMATE MILLION-TON-MILES/DAY VALUES

Current Total Airlift Capacity Is Approximately 26 or 47 MTM/Day (Without or With CRAF Stages 1-3)



Source: USAF/HQ AMC 1998 Air Mobility Master Plan.

Note: Million-Ton-Miles/Day is the product of the utilization rate, block speed, payload, and productivity factor expressed in the appropriate units.

This slide provides an illustration of the operational use of tankers in the airlift role. The approximate total number of airlift sorties in Desert Shield and Desert Storm performed by the KC-10A and KC-135 tankers (all types) are listed. Also included is the number of airlift sorties flown by the tankers in a portion of Joint Endeavor/Joint Guard (implementation of the Dayton Peace Accords in Bosnia), from its inception through the early part of 1996. This recent activity is in stark contrast to the tankers' nearly exclusive aerial refueling service during most of the Cold War.

Most of the airlift sorties performed by tanker aircraft constituted channel service, which is defined as a regularly scheduled mission over a fixed route with capacity available to all customers. Most intertheater sustainment missions fall in this category and the load can be either passengers or cargo. The two types of channel service are requirements-based and frequency-based.

OPERATIONAL USE OF TANKERS IN THE AIRLIFT ROLE

Tanker	Airlift Sorties		
	Desert Shield	Desert Storm	Joint Endeavor[a]
KC-10A	2,668	471	11
KC-135 (All Types)	2,960	913	<159[b]
Total	5,628	1,384	<170

[a]As of January 18, 1996 (operation now called Joint Guard).
[b]Includes aerial refueling missions.

The major observations from the briefing are summarized on this chart. Tankers are efficient platforms for high-priority bulk cargo and passengers. Their long range and higher speed make them suitable to fill a specialized niche in the airlift role. Tanker aircraft are playing an increasing role in peacetime and contingency airlift operations. More worldwide low-volume channel airlift missions are being flown by tanker aircraft. Using tankers to deliver cargo and passengers in wartime may aid in reducing the widely acknowledged airlift capability shortfall. AMC previously allocated 26 KC-135s and 37 KC-10As to support wartime airlift tasking.

OBSERVATIONS

- TANKERS ARE EFFICIENT PLATFORMS FOR HIGH-PRIORITY BULK CARGO AND PASSENGERS
  - Long-Range and Higher Speed Make Them Suitable to Fill a Specialized Niche in Airlift Role
- TANKERS ARE PLAYING AN INCREASING ROLE IN PEACETIME AIRLIFT OPERATIONS
  - More Worldwide, Low-Volume Channel Airlift Missions Are Being Flown
- USING TANKERS TO DELIVER CARGO AND/OR PASSENGERS IN WARTIME MAY AID IN REDUCING WIDELY ACKNOWLEDGED AIRLIFT SHORTFALL
  - AMC Previously Allocated 26 KC-135s and 37 KC-10s for Wartime Airlift Tasks

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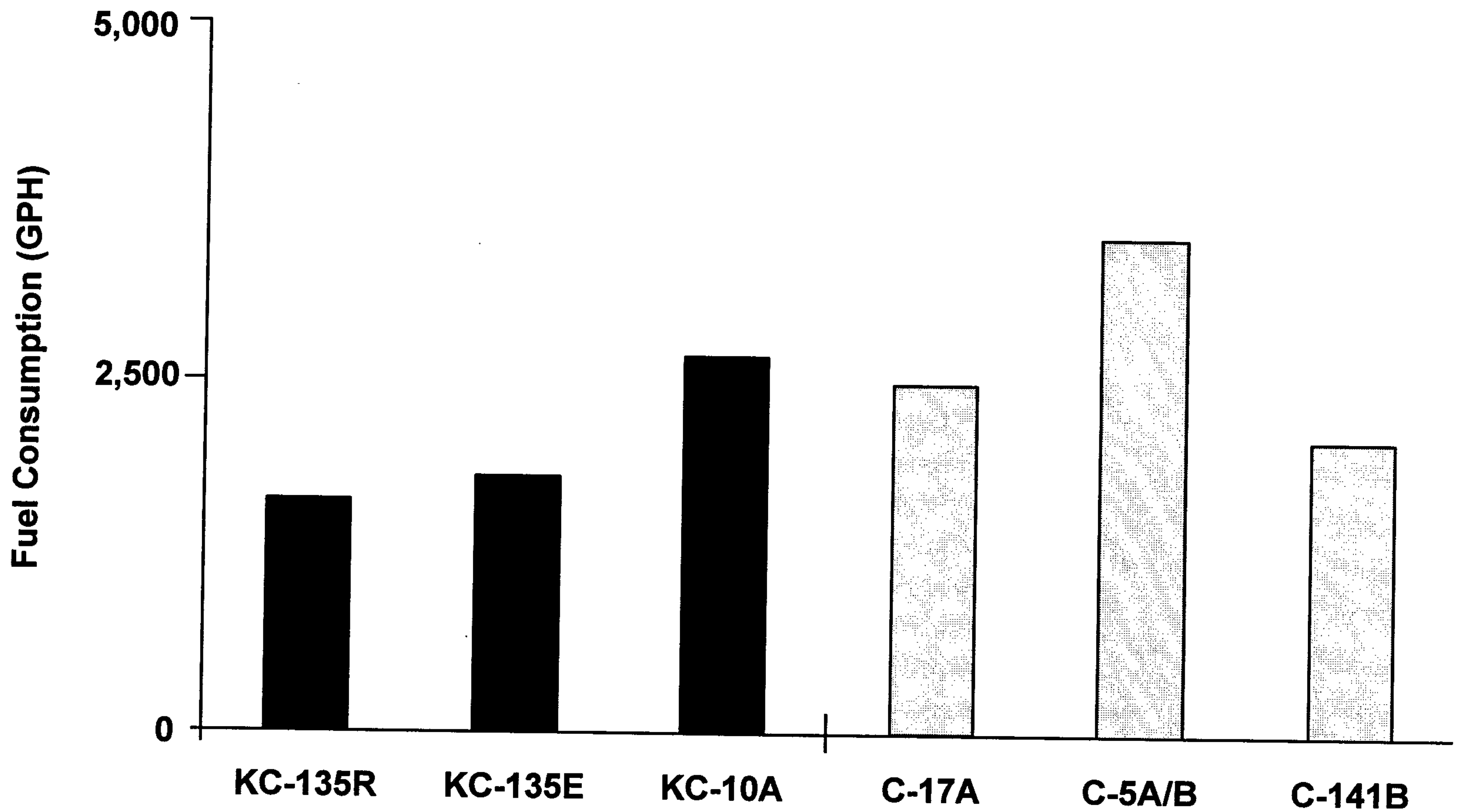
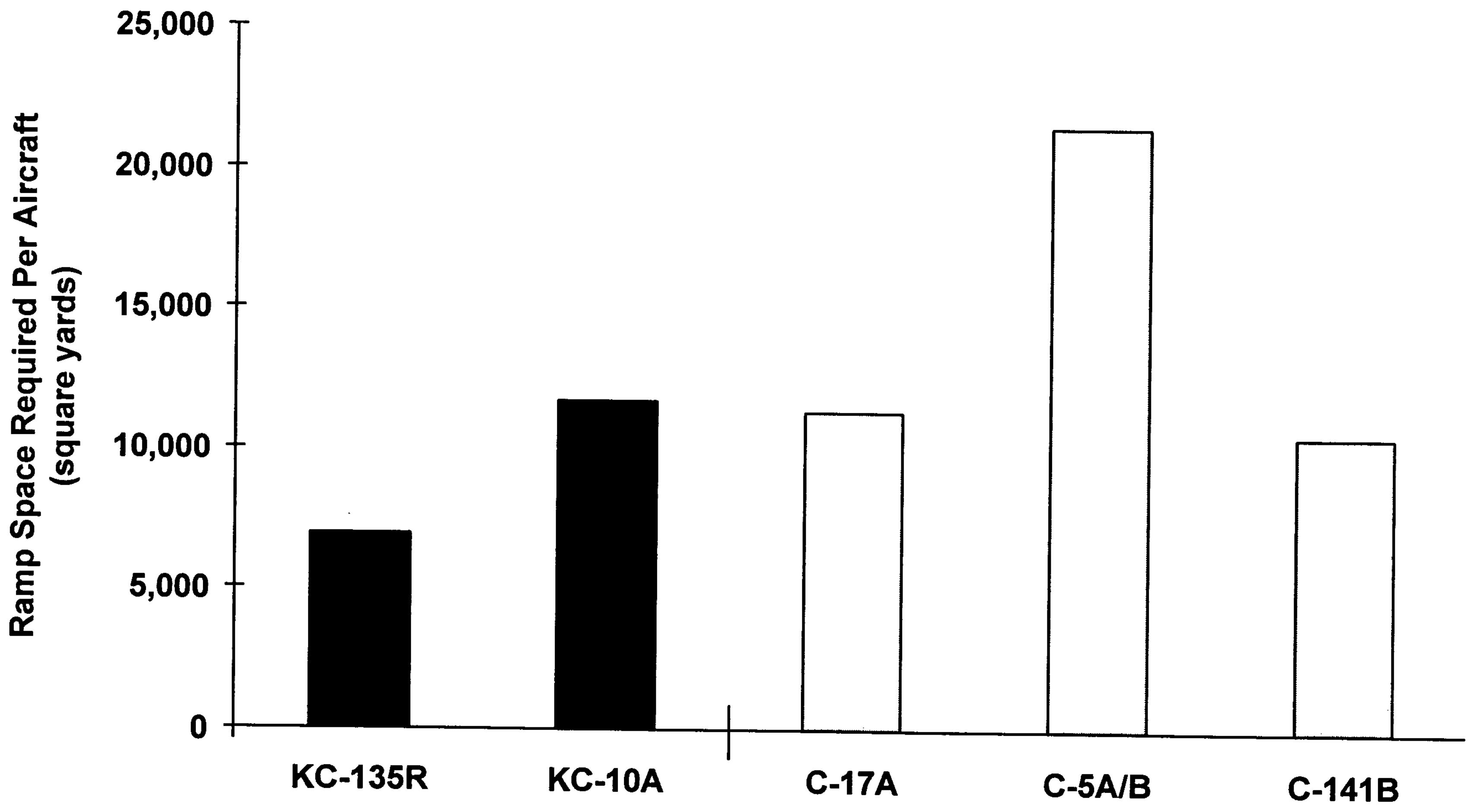
Appendix A
BACK-UP CHARTS

NOMINAL AIRCRAFT FUEL CONSUMPTION



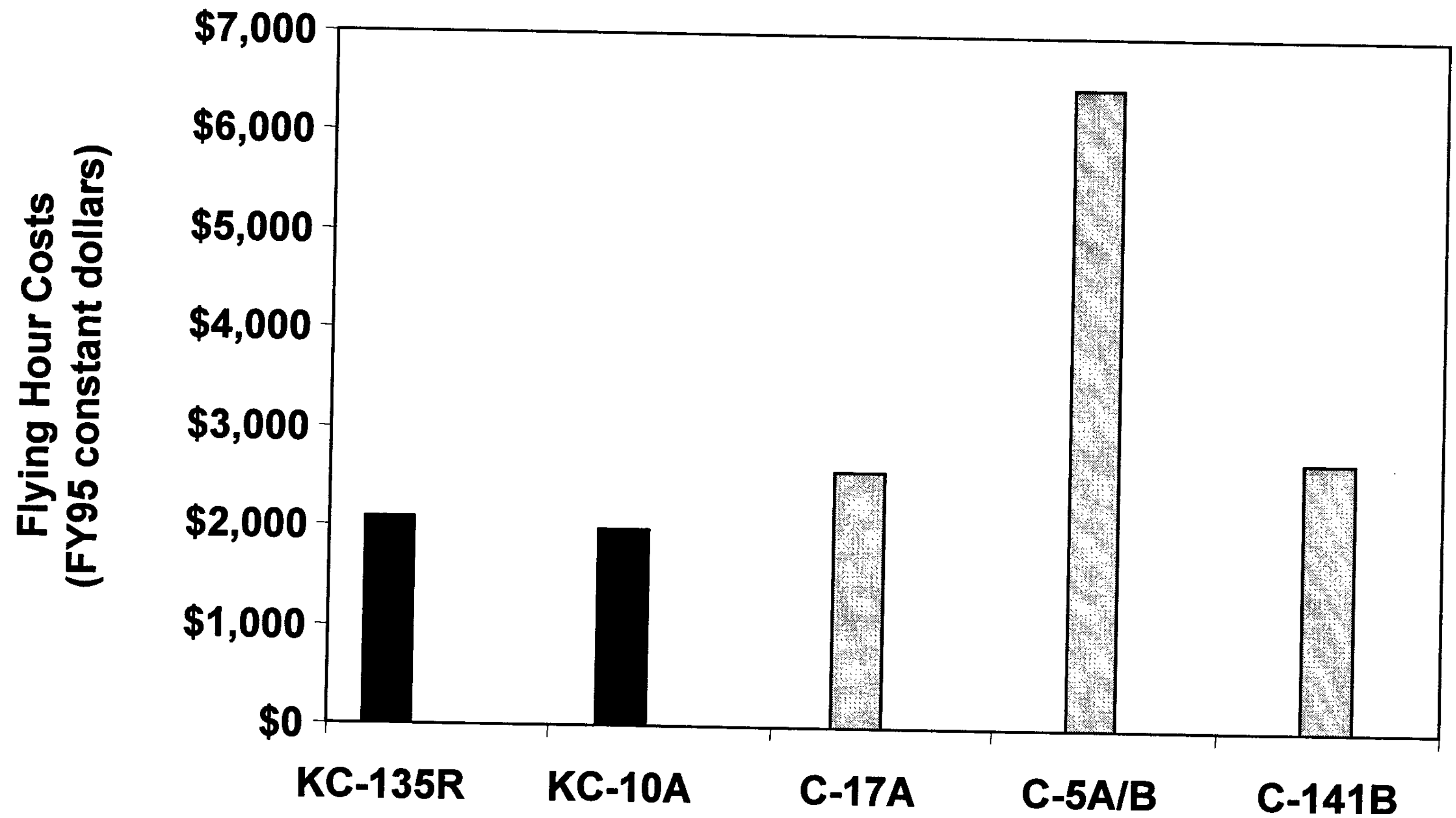
Source: Air Force Pamphlet AFP 144-4.

NOMINAL AIRCRAFT RAMP SPACE REQUIREMENTS



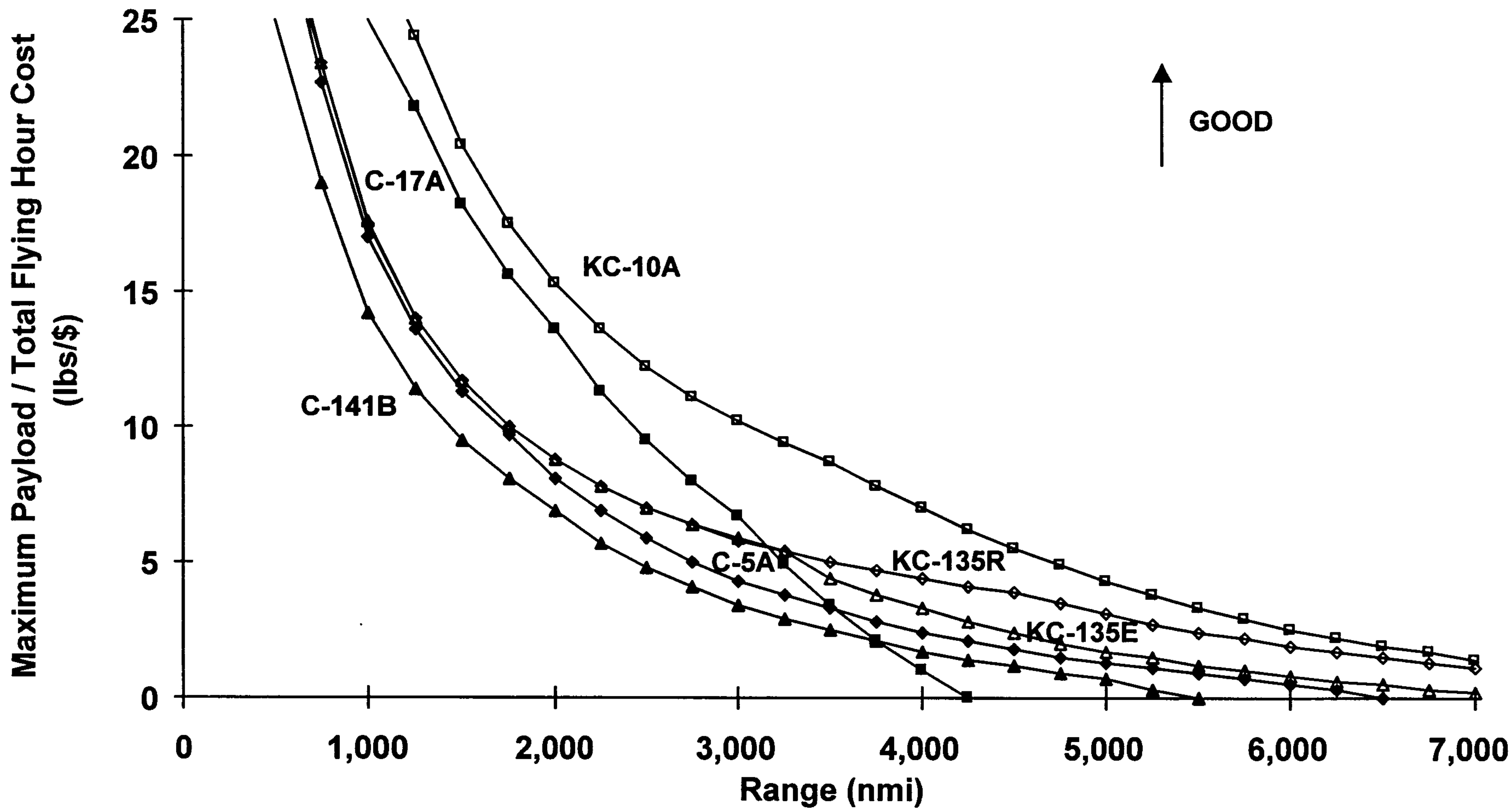
Source: AFM 86-2.

NOMINAL AIRCRAFT FLYING HOUR COSTS



Source: USAF Core Model (FY 95).
Commercial Logistics Support costs included where applicable.

PAYLOAD DELIVERY COST-EFFECTIVENESS



Note: Flying-hour costs from USAF Core Model (FY 95).
Commercial Logistics Support costs included where applicable.

Appendix B
GLOSSARY

Appendix B
GLOSSARY

AFP	Air Force Pamphlet
AMC	Air Mobility Command
AMMP	Air Mobility Master Plan
CBO	Congressional Budget Office
CLS	Commercial Logistics Support
DoD	Department of Defense
DPG	Defense Planning Guidance
GAO	Government Accounting Office
IDA	Institute for Defense Analyses
LAPES	Low-Altitude Extraction System
MHE	material handling equipment
MTM/D	million-ton-miles per day
nmi	nautical miles
PAA	primary aircraft authorized
PAX	passengers
QDR	Quadrennial Defense Review
TIA	total inventory aircraft
TOGW	takeoff gross weight

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13. ABSTRACT *(Maximum 200 words)*

This annotated briefing examines the utility of employing KC-135 and KC-10 tanker aircraft in the airlift role. The general characteristics, cargo loading capabilities, and performance of the tankers are examined and compared to the dedicated C-5A/B, C-17A, and C-141B airlift aircraft. Past operational usage of tankers in the airlift role and planning factors for future contingencies are revealed.

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